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EXPLOSIVE SHOCK TESTING OF THE FS-983 HYDROPHONE AND PREAMPLIFI--ETC(U)  
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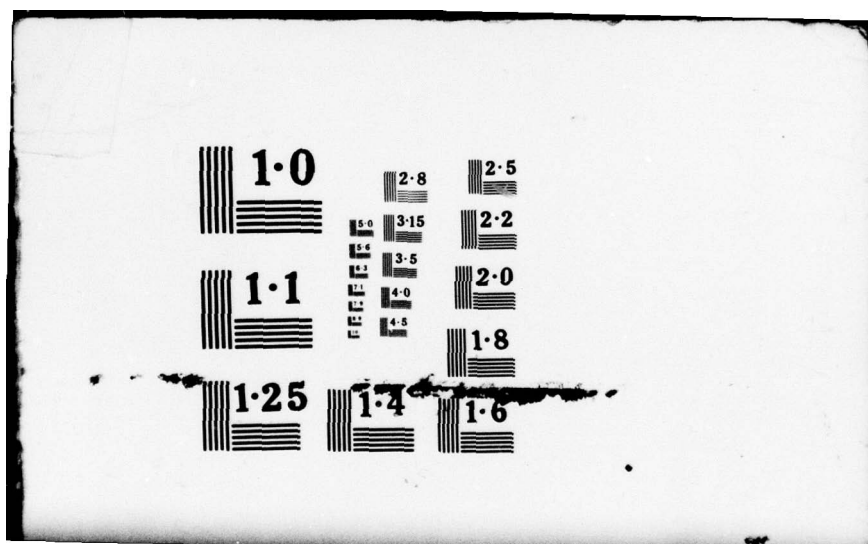
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## ABSTRACT

Two hydrophones and associated electronics were subjected to hydraulic shocks by detonating in the NSRDC test pond successively two one-pound PENTOLITE charges at a distance of 18 feet from the hydrophones. The frequency response curves of the two hydrophone-preamplifier systems before and after the shock test show no significant differences.



## INTRODUCTION

To investigate the danger of damaging hydrophone-preamplifier systems that were to be used in a proposed NSRDC active sonar test involving explosive charges, two newly calibrated hydrophones were subjected to severe underwater shock tests in the NSRDC test pond. Subsequent calibration of the tested hydrophone systems showed no significant change in their frequency response characteristics. As a reference, a third hydrophone system was calibrated together with the two other systems, without having been subjected to the shock tests. This reference system showed the same order of variance between "pre" and "post" test calibration as the tested hydrophones did.

#### DESCRIPTION OF THE TEST

The hydraulic shock tests were conducted in the NSRDC test pond on 28 February 1969. The two hydrophones to be tested were suspended from steel cables stretched across the pond. See Figure 1. The explosive charge was suspended in the middle between the cables, so that the distances to the two hydrophones were equal (18 feet). The depth of the charge and the hydrophones was 10 feet below the water surface. The pond itself is 24 feet deep.

The hydrophone-preamplifier electric cables were taped along the steel cable and brought into the measuring shed, where they were energized with the required 24-v d.c. supply. The output signal was monitored on a visicorder to be able to study the recovery time of the preamplifiers.

Two charges were detonated at a twenty-minute interval. The weight of each charge was 456 grams, slightly more than one pound. The explosive was PENTOLITE.

#### SHOCK FACTOR AND PEAK PRESSURE

It is customary to express the intensity of hydraulic shock by the shock factor  $\sqrt{W/D}$ , where W is the weight in TNT equivalent, and D is the stand-off distance in feet. Since one-pound of PENTOLITE is equivalent to 1.08 pound of TNT, the shock factor was  $\sqrt{1.08/18} = .06$ . This shock factor is within the limits that can be considered reasonably safe for hydrophone-preamplifier systems subjected to repeated hydraulic shocks.

A second measure of the shock intensity is the peak pressure at the hydrophone. From the empirical formula<sup>3,4</sup>

$$p_o = 4.83 \cdot 10^8 \left( \frac{W^{1/3}}{R} \right)^{1.13} \quad [\text{dyne/cm}^2]$$

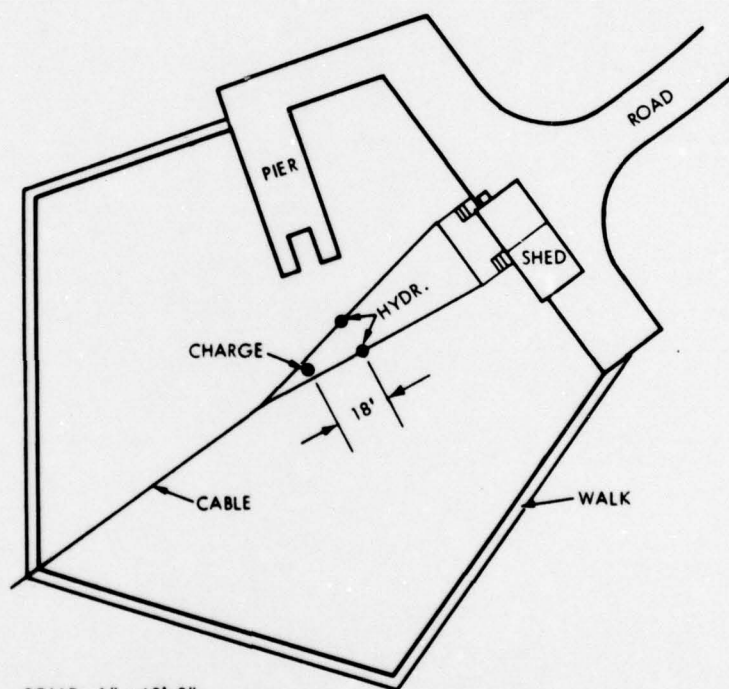
W = weight [lb TNT equiv.]  
R = distance [yds]

it follows that the peak pressure at the hydrophones theoretically reached 156 db/ $\mu$ bar. This corresponds to approximately 36 db over 1 atmosphere or 63 atmosphere.

From empirical formulae<sup>4</sup> for the time constant

$$\tau_o = 74 W^{1/3} \left( \frac{W^{1/3}}{R} \right)^{-0.22} \quad [\mu\text{sec}]$$





SCALE: 1" = 60'-0"

FIGURE 1. PLAN VIEW OF TEST POND  
AND LOCATION OF CHARGE  
AND HYDROPHONES.

and the interval between the shock wave and the first bubble pulse

$$T = 4.36 W^{1/3} \frac{1}{(Z + 33)^{5/6}} \quad [\text{sec}]$$

we find 112  $\mu\text{sec}$  for the theoretical pulse width and .2 sec for the bubble interval.

All mentioned test parameters are given in Table I.

TABLE I  
DIMENSIONS, DISTANCES AND TEST PARAMETERS

TEST POND	NSRDC
Diameter	~200 feet
Depth	24 feet
HYDROPHONES	2, energized
Type	FS 983 (ITHACO)
Serial Nos.	5424, 5429
Depth	10 feet
CHARGES	2, fired electrically
Type	PENTOLITE
Shape	Cylindrical
Weight	456 grams
Equiv. Weight	1.085 lbs TNT
Depth	10 feet
STAND-OFF	18 feet
SHOCK FACTOR	.06
PEAK PRESSURE	156 db/1 $\mu\text{bar}$ = 63 at.
Pulse Width	110 $\mu\text{sec}$
Bubble Interval	.2 sec

#### COMPARISON OF FREQUENCY RESPONSE CURVES

The calibration curves, given in Figures 2 through 4, show the frequency responses of the hydrophone system before and after the shock test. One hydrophone system (serial #5425) was not shock tested, but was calibrated along with the other two for reference purposes. The calibration measurements were done by the NOL Acoustic Facility in Lake Tridelphia near Brighton, Maryland.

The minor differences between the "pre" and the "post" test calibration curves are due to variance in the measurement, since the same order of deviation is apparent in the non-shock tested sample (#5425). Also, the differences between the curves are larger at high frequencies, where the results of the measurements are more sensitive to small changes in the test conditions.

It may therefore be concluded that the characteristics of the two tested hydrophone-preamplifier systems have not changed as a result of two hydraulic shocks, and that the operational performance has not been impaired.



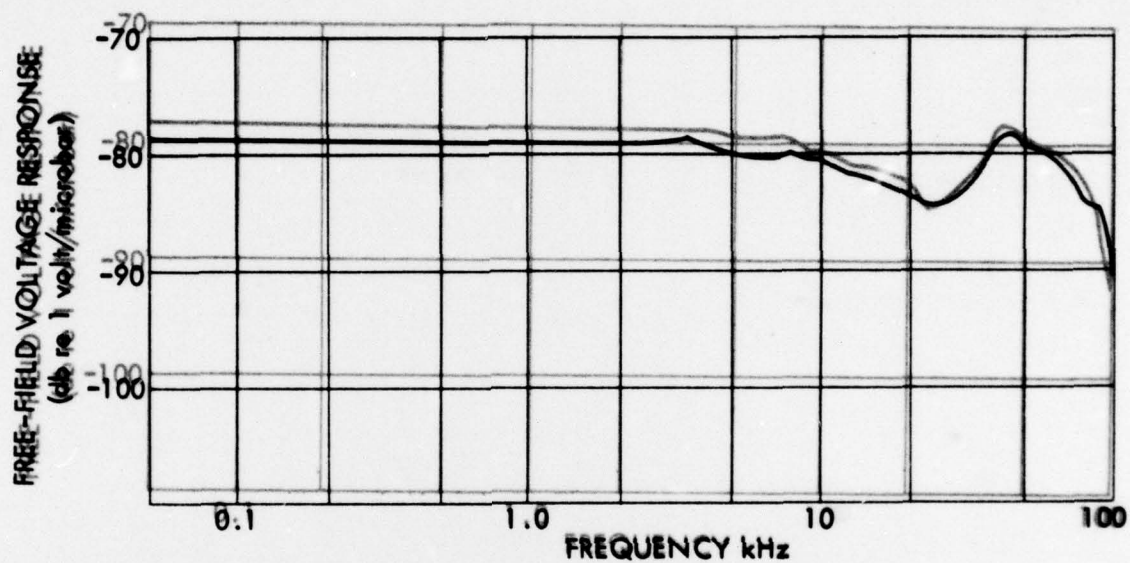


FIGURE 2b:  
HYDROPHONE F5983-5424  
DATE 24 FEBRUARY 1969  
(BEFORE SHOCK TEST)



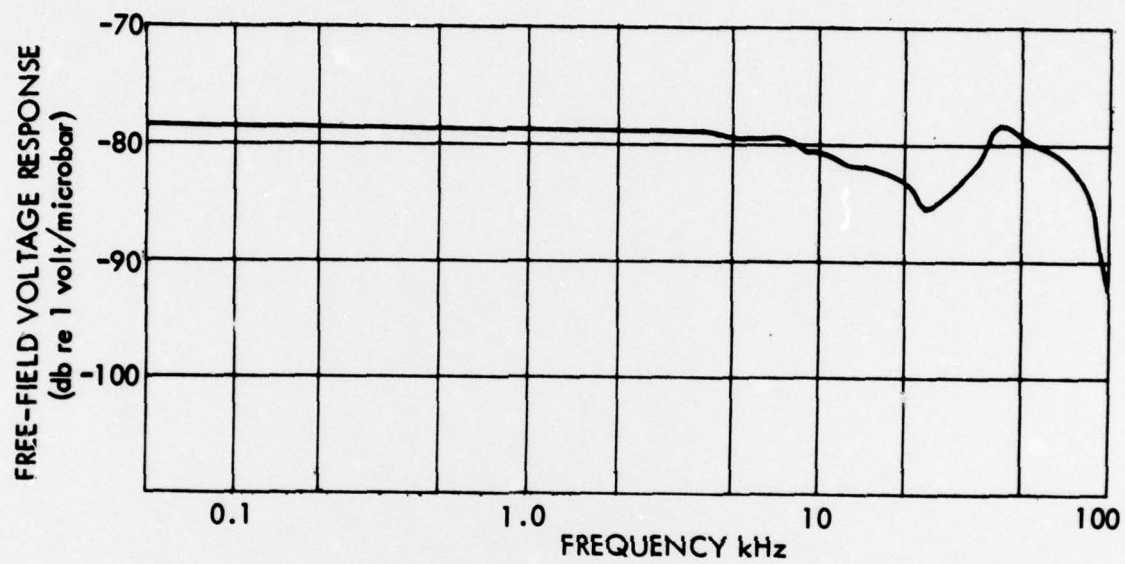


FIGURE 2b.  
HYDROPHONE FS983-5424  
DATE 16 APRIL, 1969  
(AFTER SHOCK TESTS)

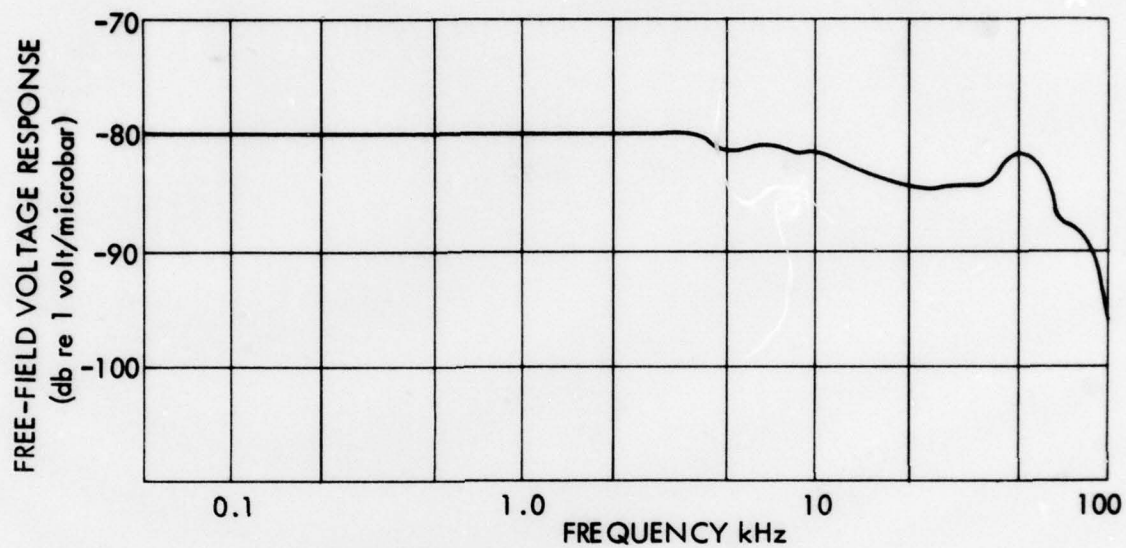


FIGURE 3a  
HYDROPHONE FS983-5429  
DATE 24 FEBRUARY, 1969  
(BEFORE SHOCK TEST)

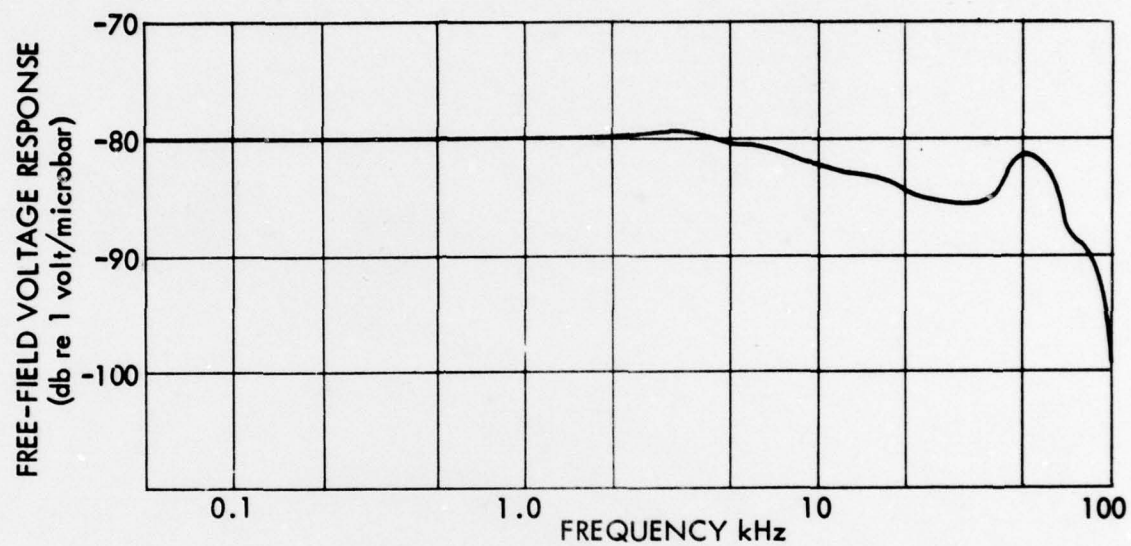


FIGURE 3b.  
HYDROPHONE FS983-5429  
DATE 16 APRIL, 1969  
(AFTER SHOCK TEST)

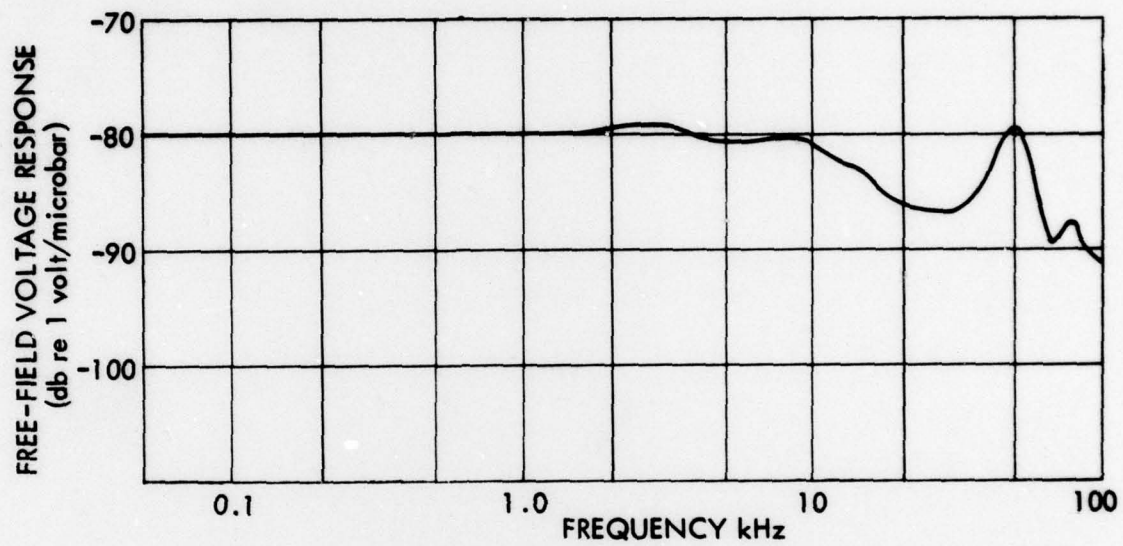


FIGURE 4a.  
HYDROPHONE FS983-5425  
DATE 24 FEBRUARY, 1969  
(BEFORE SHOCK TEST)



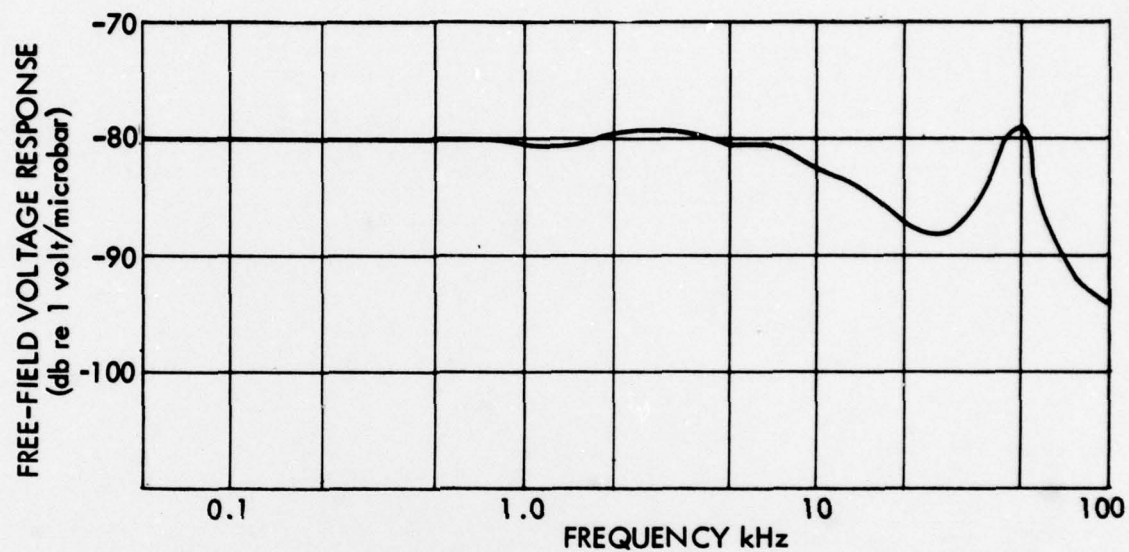


FIGURE 4b.  
HYDROPHONE FS983-5425  
DATE 16 APRIL, 1969  
(NOT SHOCK TESTED)

#### ACKNOWLEDGEMENTS

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The personnel of the NOL Acoustic Facility at Brighton, Maryland, for their accurate calibrations of the hydrophone systems.

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